

1 TO WHOM IT MAY CONCERN:

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3 BE IT KNOWN THAT WE, RICHARD R. TRACY, a  
4 citizen of the United States of America, residing in  
5 Carson City, in the County of Ormsby, State of Nevada,  
6 and JAMES D. CHASE, a citizen of the United States of  
7 America, residing in Reno, in the County of Washoe,  
8 State of Nevada, have invented a new and useful  
9 improvement in

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11 LIFT AND TWIST CONTROL USING TRAILING

12 EDGE CONTROL SURFACES ON SUPERSONIC

13 LAMINAR FLOW WINGS

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**BACKGROUND OF THE INVENTION**

This application is a non-provisional application based on provisional application Serial No. 60/441,934, filed January 24, 2003.

Supersonic aircraft designed with thin, low sweep wings designed for extensive natural laminar flow tend to have low torsional stiffness. In subsonic flight the center of pressure is typically ahead of the wing torsional elastic center creating a moment twisting the wingtip to higher angle of attack - "wash-in". At supersonic conditions the center of pressure is much closer to the wing elastic center, reducing or reversing the "wash-in". A wing with a twist distribution optimized for supersonic cruise will thus have significant "wash-in" at subsonic speeds. This induces pre-mature tip stall, reducing the maximum achievable wing lift and creating undesirable control characteristics, at stall.

Thin supersonic airfoil sections with low camber also have significant drag penalties at subsonic conditions due leading edge vortex drag. This penalty increases at high subsonic Mach number cruise conditions with a pronounced drag rise.

1           There is need for improvements in thin,  
2 supersonic wings, as disclosed herein.

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4                   **SUMMARY OF THE INVENTION**

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6           The above described problems and difficulties  
7 can be mitigated by deflection of trailing edge control  
8 surfaces on such supersonic aircraft. A trailing edge  
9 flap has the effect of moving the center of pressure  
10 aft, thus reducing the wash-in effect when deployed at  
11 subsonic speeds. The trailing edge flaps also  
12 introduce aft camber which reduces subsonic leading  
13 edge vortex drag and compressibility drag rise.

14           The present invention provides trailing edge  
15 flaps on thin supersonic wings with deflections  
16 scheduled to simultaneously control wing twist and  
17 reduce drag when operated at subsonic conditions. The  
18 surfaces of the flaps can be deflected either  
19 statically or dynamically to control twist and drag.  
20 For a static system, deflection can be set based on the  
21 nominal flight condition much as conventional landing  
22 flaps. Dynamic operation involves a closed loop  
23 feedback system which continuously monitors flight  
24 conditions and wing twist to minimize drag and/or

1 suppress dynamic wing deflections such as divergence or  
2 flutter.

3 Accordingly, it is a major object of the  
4 invention to provide an aircraft comprising

5 a) a fuselage,

6 b) thin supersonic wings on the  
7 fuselage,

8 c) there being trailing edge flaps carried  
9 by the wings,

10 d) said flaps configured to provide flap  
11 deflection to simultaneously control wing twist and to  
12 reduce drag, when the aircraft is operated at subsonic  
13 flight conditions.

14 As will be seen, the wings may typically have  
15 low sweep angularity relative to the fuselage to  
16 provide substantial laminar airflow, the wings further  
17 characterized as having relatively low torsional  
18 stiffness.

19 Further, the wings are typically  
20 characterized as having

21 a) a center of pressure, at subsonic flight  
22 conditions,

23 b) a torsional elastic center.

24 Flap deflection is provided such that the center of  
25 pressure is substantially closer to said torsional

1 elastic center under subsonic flight conditions, than  
2 in the absence of said flaps.

3 Another object is to provide flaps that are  
4 characterized by camber acting to reduce subsonic wing  
5 leading edge vortex drag, and compressibility drag  
6 increase.

7 Yet another object is to provide means  
8 for monitoring wing twist, and to control flap  
9 angularity to reduce said twist, thereby providing  
10 closed loop feed back. A control system is typically  
11 provided to monitor flight conditions including air  
12 speed, and to position the flaps.

13 These and other objects and advantages of the  
14 invention, as well as the details of an illustrative  
15 embodiment, will be more fully understood from the  
16 following specification and drawings, in which:

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#### 18 **DRAWING DESCRIPTION**

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20 Figs. 1-3 schematically show wing chord, and  
21 flap configuration;

22 Figs. 4 and 6 show aircraft with supersonic  
23 wing and flap configuration, wherein Fig. 4 shows flaps  
24 during landing; Fig. 5 shows flaps during subsonic

1 cruise condition; and Fig. 6 shows flaps during  
2 supersonic cruise conditions.

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#### DETAILED DESCRIPTION

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6 Figs. 1-3 illustrate the conditions referred  
7 to above. To repeat, supersonic aircraft designed with  
8 thin, low sweep wings designed for extensive natural  
9 laminar flow tend to have low torsional stiffness. In  
10 subsonic flight (see Fig. 1) the center of pressure is  
11 typically ahead of the wing torsional elastic center  
12 creating a moment twisting the wingtip to higher angle  
13 of attack - ''wash-in''. At supersonic conditions (see  
14 Fig. 2) the center of pressure is much closer to the  
15 wing elastic center, reducing or reversing the ''wash-  
16 in''. A wing with a twist distribution optimized for  
17 supersonic cruise will thus have significant ''wash-  
18 in'' at subsonic speeds. This induces pre-mature tip  
19 stall, reducing the maximum achievable wing lift and  
20 creating undesirable control characteristics, at stall.

21 The present invention provides trailing edge  
22 flaps 10 on thin supersonic wings 11 with deflections  
23 scheduled to simultaneously control wing twist and  
24 reduce drag when operated at subsonic conditions. The  
25 surfaces can be deflected either statically or

1 dynamically to control twist and drag. For a static  
2 system, deflection would be set based on the nominal  
3 flight condition much as conventional landing flaps.  
4 Dynamic operation would involve a closed loop feedback  
5 system which continuously monitors flight conditions  
6 and wing twist to minimize drag and/or suppress dynamic  
7 wing deflections such as divergence or flutter. See  
8 flap controls 12 (schematics) in Figs. 4 and 5.

9           Nominal positions for flap deflection are  
10 illustrated in Figs. 4 and 5. Trailing edge surfaces  
11 are deflected modestly for typical subsonic conditions.  
12 Landing and takeoff involve greater deflection as is  
13 typical of conventional aircraft. For supersonic  
14 cruise they would be faired. See Figs. 4-6. The  
15 fuselage is indicated at 13.

16           In summary, the aircraft of the invention  
17 has:

- 18           a) a fuselage
- 19           b) thin supersonic wings on the  
20 fuselage,
- 21           c) trailing edge flaps carried by the  
22 wings,
- 23           d) the flaps configured to provide flap  
24 deflection to simultaneously control wing twist and to  
25 reduce drag, when the aircraft is operated at subsonic  
26 flight conditions.

1                   Typically, the wings have low sweep  
2   angularity relative to the fuselage to provide  
3   substantial laminar airflow, the wings further  
4   characterized as having relatively low torsional  
5   stiffness.

6                   The wings are further characterized as having  
7                   d)    a center of pressure, at subsonic flight  
8   conditions,

9                   e)    a torsional elastic center,  
10   and wherein in the absence of flap deflection at  
11   subsonic flight condition the center of pressure is  
12   forward of said torsional elastic center, tending to  
13   create moments of force acting to twist the wing tip to  
14   higher angles of attack.

15                  In the absence of such flap deflection the  
16   center of pressure is substantially closer to said  
17   torsional elastic center, under supersonic flight  
18   conditions, than under subsonic flight conditions.  
19   Further, the center of pressure is substantially closer  
20   to the torsional elastic center under subsonic flight  
21   conditions, than in the absence of such flaps.

22                  Further, the flaps provide camber acting to  
23   reduce subsonic wing leading edge vortex drag, and  
24   compressibility drag increase.

25                  The invention also provides means for  
26   monitoring wing twist, and to control flap angularity



1 to reduce said twist, thereby providing closed loop  
2 feed back. A control system or systems maintains the  
3 flaps positioned to control twist and drag, at subsonic  
4 flight conditions. The control system or systems is  
5 configured to monitor flight conditions including air  
6 speed, and to position the flaps, as described.

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